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STUDIES ON THE TRANSPORT-PHENOMENA WITH EXCISED AND INTACT WHEAT ROOTS

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Abstract

Authors studied the membrane-bound ATP-ase activity, K^+ uptake and 2,4-D sensitivity of young wheat roots, and compared the transport characteristics of the excised roots and intact plants. The obtained results could be summarized as follows:

1. The 0.01 mM 2,4-D in the uptake solution evidenced greater inhibition of the ATP-ase enzyme functioning in the case of the excised roots than in that of the intact plants. This inhibitory effect was always found to be more expressed in the plants grown in 5×10^{-4} M $CaSO_4$ solution than in those grown in complete nutrient solution.
2. The Viets-effect as well as the effect of the various stress factors was demonstrable both in the case of excised and intact plants, however, in the latter case the K^+ uptake stimulated by Ca^{2+}, and the K^+ content was higher.
3. The differing transport-phenomena experienced between the excised and intact plants could be explained by the joint effect of the various environmental factors and the excision.

Key-words: excised and intact roots, ATP-ase activity, ion uptake .

Introduction

The excised roots have been since long the favoured experimental objects of researchers dealing with ion transport (EPSTEIN, 1972). Nevertheless, it is also known that under certain conditions the ion uptake of the excised roots may vary from that of the intact plants (GLASS, 1978; PARRONDO et al., 1976). It has frequently been experienced in our own experiments that the results obtained with excised roots show greater variation than the results of experiments carried out with whole plants. SACCOMANI et al., (1981) have reported that the uptake of sulphate ion shows greater variation in the case of excised maize roots than in the case of intact plants. The measurements regarding the bulk of the sulphate pool also provide differing results in correlation with the type of plant used in the experiment.

During the course of our experiments the transport characteristics of the excised roots and intact plants were compared from several view-points. The preparable membrane-bound ATPase activity, the changes taking place in the enzyme on the effect of pH stress and 2,4-D were studied. The Ca^{2+}-activated K^+ uptake as well as the pH-dependency of the process was also examined.

Materials and methods

Wheat seedlings were used for the experiments (*Triticum aestivum* L. cv. GK-Szeged). The plants were grown according to the conditions reported on earlier (ZSOLDOS et al., 1978). In accordance with the character of the experiments the nutrient solution was 5×10^{-4} M $CaSO_4$ and modified Hoagland nutrient solution, respectively. For the comparison of the transport-phenomena of the excised roots and intact plants, one part of the plants was placed in the uptake solution series (containing 5 mM KCl, 0,5 mM $CaCl_2$ in the presence and absence of 0,01 mM 2,4-D) in intact condition (shoot and root system together), in the other part only the excised roots were placed in the solution series. The pH of the solutions was checked at the beginning and end of the experiments and the uptake systems were regularly bubbled. After 3 hours the amount of K^+ uptake was measured (ZSOLDOS et al., 1978), the ATP-ase enzyme of the root was prepared and the activity was measured according to data published earlier (ERDEI et al., 1977). The experiments were repeated three times and the present paper comprises the results of a characteristic series.

Results and evaluation

Figure 1 demonstrates the transport ATPase activity of the intact plants. On the upper part of the Figure (A) the data of the roots grown in 5×10^{-4} M $CaSO_4$ are shown, while the lower part (B) demonstrates the results of plants grown in Hoagland nutrient solution. Leaving the wheat roots in uptake solution of pH 4 for a period of 3 hours resulted a higher activity of the prepared ATPase enzyme than in the case of the roots of pH 7. Comparing the plants kept in $CaSO_4$ and nutrient solution, in the latter case the enzyme activity was found to be higher than pH 7. There was a significant difference in the change of activity observed on the effect of 0,01 mM 2,4-D. In the case of the plants grown in $CaSO_4$ an inhibition of 28% was measured at pH 4, while this was 20% in the case of the plants grown in nutrient solution. It was of further interest that at pH 7, 2,4-D did not cause significant changes in the case of $CaSO_4$-grown roots, while the degree of inhibition was found to be 15% in the case of those grown in nutrient solution.

Comparing the results with the data of Figure 2 further interesting differences are gained. The growing of the plants and the setting of the experimental systems was the same as the previous, only in present case excised roots were used. The inhibition of 2,4-D was much more expressed than in the case of the intact plants. The higher ATP-ase activity measured at acidic pH also appeared in these experiments. Regarding the roots kept in $CaSO_4$ (pH 4) in the presence of 0,01 mM 2,4-D, the enzyme activity was lower by more than 40%, and by 30% in the case of the plants kept in nutrient solution. At pH 7 an inhibition over 17% was measured in the case of the $CaSO_4$-grown roots, contrary to the intact plants where these was no significant change. Opposite effect was experienced also in the case of the roots grown in nutrient solution; a stimulation of low degree was observed regarding the excised roots, while an inhibition of more than 15% was obtained in the case of the intact plants.

According to the earlier studies 2,4-D, at acidic pH, significantly inhibited the NH_4^+, NO_3^-, K^+ and phosphate ion uptake of excised wheat roots (ZSOLDOS and HAUNOLD, 1979), as well as the K^+, NH_4^+, and NO_3^- uptake of excised rice roots (ZSOLDOS and HAUNOLD, 1982). Since the active ion uptake takes place demonstrably on the ATP-ases localized in the membrane or with the intervention of ATPase-like proteins (LEONARD and HOTCHKISS, 1976; TÓTH, 1980; ERDEI et al., 1982), the changes in transport could also be concluded from our present investigations.

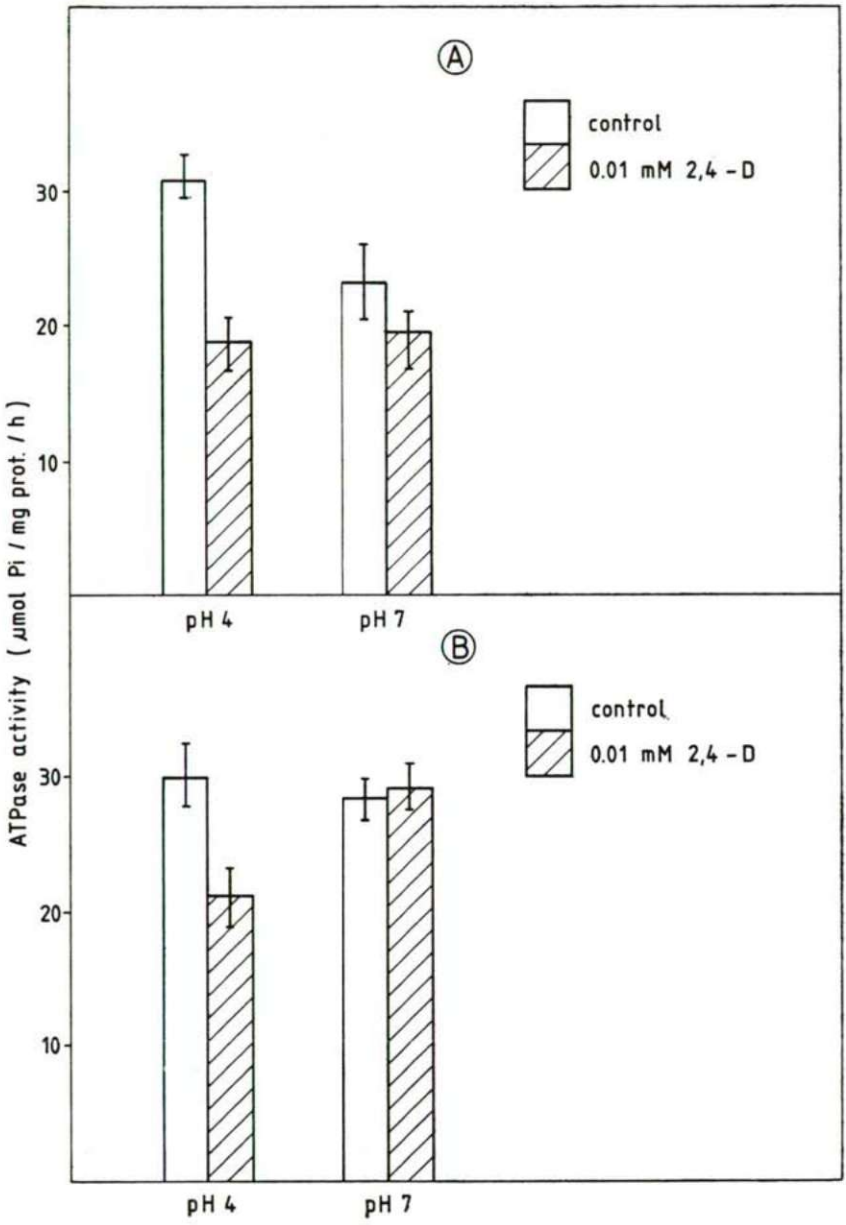

Fig. 1. Membrane-bound ATP-ase activity of 1 week old wheat roots (*Triticum aestivum* L. cv. GK-Szeged) grown in 5×10^{-4} M $CaSO_4$ (A) and modified Hoagland nutrient solution (B), at varying pH and in the presence and absence of 0,01 mM 2,4-D. The uptake solution contained 5 mM K^+ and 0,5 mM Ca^{2+}, the experimental period was 3 hours. Intact plants were used in the experiment.

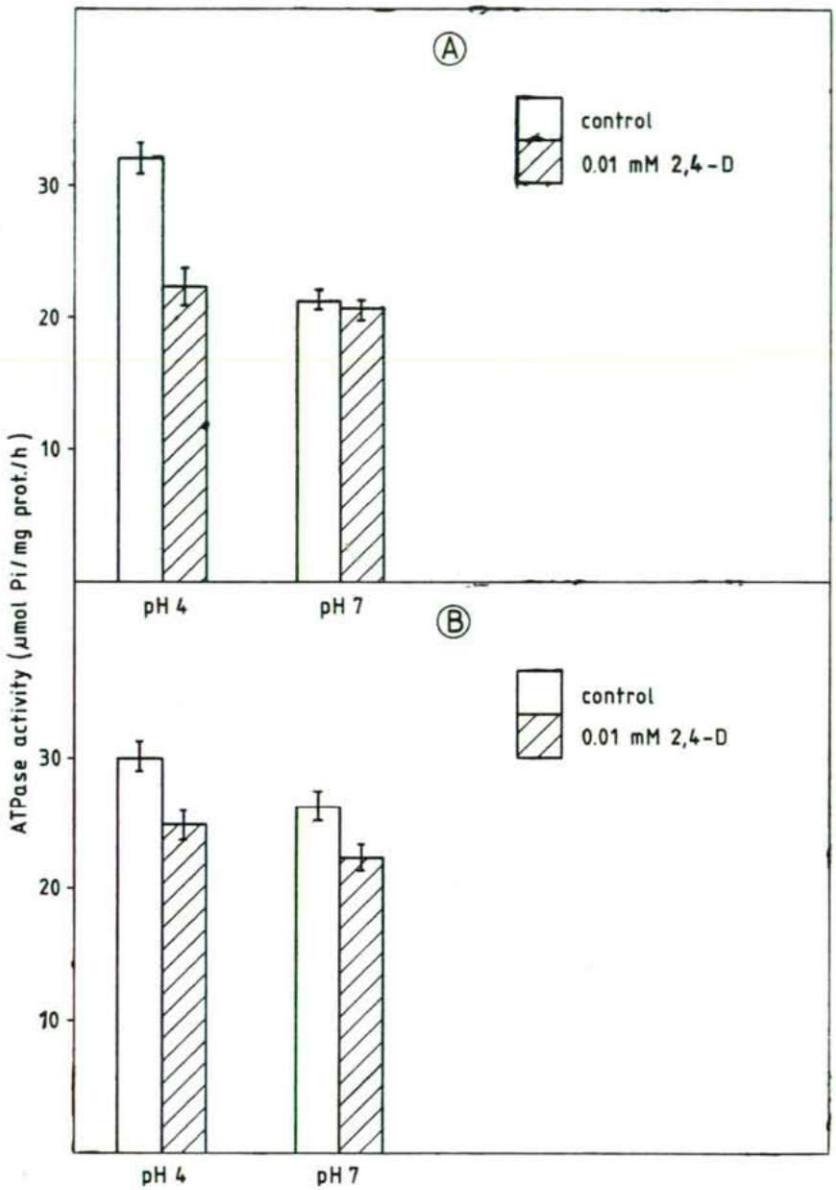

Fig. 2. Membrane-bound ATP-ase activity of 1 week old wheat roots (*Triticum aestivum* L. cv. GK-Szeged) grown in 5×10^{-4} M $CaSO_4$ (A) and modified Hoagland nutrient solution (B), at varying pH and in the presence and absence of 0,01 mM 2,4-D. The uptake solution contained 5 mM K^+ and 0.5 mM Ca^{2+}, the experimental period was 3 hours. Excised roots were used in the experiment.

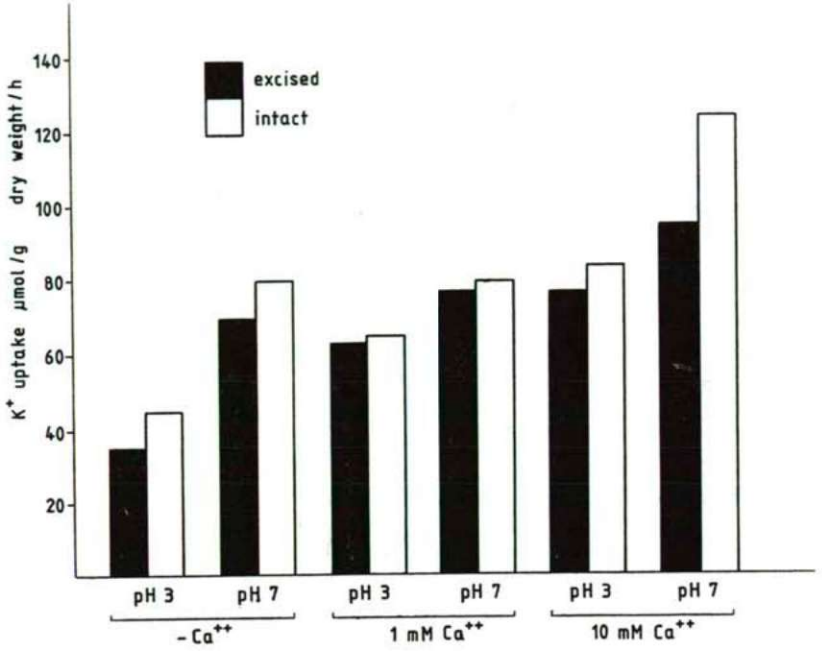

Fig. 3. K^+ uptake of excised and intact wheat roots in the presence and absence of Ca^{2+}, besides varying pH conditions. The uptake solution contained 5 mM K^+ and 0,5 mM Ca^{2+}, the experimental period was 1 hour.

Figure 3 shows the development of the K^+ uptake measured in the presence and absence of Ca^{2+}, in the case of excised roots and intact plants. It could be determined that in the case of the intact plants, the Viets-effect (VIETS, 1944) — that is the K^+ uptake stimulated by Ca^{2+} — was more expressed in every case and in general, the K^+ uptake was higher than in the case of the excised roots.

On the basis of our results it could be concluded that although the excised roots — due to their easy handling — were rather ideal experimental plants for the studies on ion transport, the results obtained are not always in accordance with the happenings taking place in the intact plants. The obtained results show a greatly higher variation and contrary effects may be measured many times. The excision of the root, the separation of the root system from the shooting — the ceasing and modification, resp., of the xylem and phloem transport — is such a stress factor which influences the physiology of the roots; in the present case, the transport characteristics. Since there are plants probably sensitive and less sensitive to stress effects, the question necessitates further studies.

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